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ABSTRACT

The author implies or mentions in general that many factors, such as economic, cultural, psychological and political, all interacting with one another, determine the state of society and more specifically that of our environment. Basically, however, he attempts to identify how engineering and technology fit into the situation. He states, as a simple fact that, within the context of our cultural and societal traditions and practices, the by products of technology we have all demanded, encouraged, and supported, have created the great environmental perils that now confront society. The purpose of the Conference at which this paper was presented was an inquiry into ways the state's engineering colleges may most appropriately respond to the needs created by environmental problems. The author speaks to the idea that the good engineer must be sensitive to the social forces of his time and must be educated toward this goal. Curriculum and research procedures must be revised to enhance the social awareness and responsibility of scientists and engineers. (EB)

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ENGINEERING EDUCATION AND THE EFFLUENT SOCIETY

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## ENGINEERING EDUCATION AND THE EFFLUENT SOCIETY

Mr. Chairman, Gentlemen:

Some time ago, Frank Kille tempted me with the prospect of speaking to you this evening. I finally accepted on the basis of Frank's assurance that I would meet some of the finest people in the academic community. This reminds me of a story.

It is the story of the State Trooper in Albany on the Thruway who saw, coming down the road in his sports car about eighty miles an hour, a young fellow, and the trooper pulled him over to the side of the road and was about to write him a ticket when the young man said: "Wait a minute, Officer, you don't understand, I am from one of the finest families in New York State." The Officer said, "That doesn't make any difference, son, you know. We are not arresting you for breeding purposes."

Finding myself, a misbehavioral scientist, up to my neck in a group of engineers, gives me some pause and maybe I shouldn't speak at all. And so I am reminded of another story. You don't need this story but I need to tell it to you.

It concerns a Russian peasant who was walking along the road on his way to work on a cold day, indeed, in Siberia. He came upon a small sparrow, half-frozen to death. The compassionate peasant picked up the bird, tucked it in his coat, and proceeded to work. But suddenly he realized

the bird was not reviving fast enough, and just at that point a troika of horses sped past, dropping a pile of hot, steaming manure in the road. The peasant had an inspiration and tucked the bird into the warm manure up to his neck. Sure enough the bird began to revive, uttered a faint chirp, and burst into song. Unfortunately, a fox heard the bird, loped over and swallowed him whole.

All Russian stories have morals, and this one has, too. First, those who put you into it up to your neck are not always your enemies. Secondly, those who take you out of a pile of it are not always your friends. And thirdly, if you find yourself up to your neck in a pile of it, for Christ's sake keep your mouth shut.

But the people of this state expect their Commissioner of Education to meet every issue -- with an open mouth, and so I'll talk for a few minutes about engineering education, environmental problems, and the State Education Department.

Holding conferences on environmental problems is the most rapidly growing phenomenon today in our society. It illustrates the ubiquity of environmental problems and peoples' concern with them. We find this in all sectors of society. Government, industry, schools, universities, labor, professional societies, foundations, conservation groups, theologians, and a variety of citizens' organizations, all have spoken out or mounted programs of one kind or another. The striking feature about the statements coming from

this widely diverse group is that there is only small disagreement about the assumption that we are, environmentally speaking, in serious trouble. Also, there are no significant opposition groups, only individuals. Exactly how serious the trouble is right now is a matter of some disagreement. The question of just when we'll pass the point of no return, if we haven't already, and the question of which specific problem may be the prime one, also find some differences of opinion. But again, the virtual unanimity of opinion that our society faces a peril, emphasizes the seriousness with which this problem must be faced.

Having said these things, I am compelled to say something else. We have what amounts to a new environmental evangelism. Some of the zealots are guilty of a kind of "intellectual overkill." Brzezinski, the scholar, recently lamented the self-flagellating mood that has seized a good part of the American intellectual world and spoke of the fashionable talk today on the subject of the country's imminent doom and remarked that the more pessimistic the prediction, the louder, the acclaim. To this, Saul Bellow, the novelist, I think would respond:

Maybe civilization is coming to an end, but it still exists, and meanwhile we have our choice: We can either rain more blows on it, or try to redeem it.

Someone said recently that to these doomsday prophets, he would suggest a reversal of the usual American advice and recommend part of the

philosophy of Buddha: "Don't just do something, stand there." To these, ecology may be the last fad.

Visceral or glandular predictions of early doom can result in the loss of credibility for the serious problems that do lie ahead.

And then we have a group of amateur ecologists who carry on a great American tradition, by giving issues and problems of an affluent society only a glancing blow.

For these, the new environmental crusade may become a passing fad.

And there are signs of a backlash emerging in the ecology drive, with one University of Minnesota Professor forecasting that the ecology movement, far from uniting the country as it once was thought (Earth Day) will prove to be more divisive than black power or the war in Vietnam, because ecology demands more fundamental changes than any other revolution. I am reminded that liberality often vanishes with personal inconvenience. And Professor Milton Friedman, the University of Chicago economist, strongly urges that the real culprit is not the industrial polluter but the consumer who doesn't seem to want to change his buying habits much.

And it has not gone unnoticed by some hard-right, rock-bound citizens and newspapers that Earth Day fell on Lenin's birthday, and, therefore, Earth Day was communist-inspired.

All of us here are surely familiar with descriptions of the environmental problem and I need not elaborate.

I would, however, like to comment on a few of the developments which have been taking place on some of the academic scenes, in the schools and in the institutions of higher learning. The first is the almost wild proliferation of added courses treating the subject of the environment in the many academic disciplines. We find courses with such diverse titles as "Economics and the Environment," "Environmental Architecture and Design," "Man's Health and the Environment," "Environmental Law," "Environmental Education," "Environmental Chemistry," "Electrical Power Generation and the Environment," and, of course, courses under the general rubric of "Engineering and the Environment."

In no sense is this listing meant to be facetious. It is meant to illustrate the profound concern that individuals from virtually all disciplinary areas have with environmental problems. It is interesting to note, by the way, that the preceding recital of courses implicitly contains the information that the disciplinary areas are still maintaining their own identity. However, the pressure for action in the environmental field has been so great and unrelenting that signs of some reorganization of departmental structures and faculty alignments in the universities are beginning to appear and rightly so.

The necessity for multidisciplinary efforts and structural and curricular reorganizations of one kind or another on the academic scene to cope adequately with environmental problems, has long been called for by many people. Professor Paul D. Hurd of Stanford commented a couple of years ago:

The present orientation of education distorts the efforts of young people to understand ecological health within the framework of a humane society. The knowledge demanded to attack these problems is isolated with separate disciplines and is taught without regard to its relevance for man's existence. The curriculum organization that is called for must insure collaboration between the social and natural sciences including the humanities and engineering if man is to plan responsibly for improving his environment.

Little progress will be made . . . unless we can reduce the present polarity within the curriculum and establish interdisciplinary courses and programs.

This same theme has been stressed by other studies and reports, some at high levels. In short, the plea is that there is a bright future for complexity, that our vital social problems represent a degree of complexity not known hitherto, and that therefore there is need for multidisciplinary and interdisciplinary advanced training to provide the kind of leadership required for attacking the major problems of poverty, pollution, and population control. Dr. Mina Rees, Graduate Dean of the City University of New York, states that doctoral programs are needed that build on scholarship in several disciplines but focus their research on social issues and she then goes on to say that she is talking about developing the art of social engineering. This implies, I think, a more humanistic approach which I shall speak of later.

The universities and colleges have been responding. Interest in their activities produced one survey by the Environmental Policy Division of the Library of Congress' Legislative Reference Service. It describes programs in environmental science centers in junior colleges, liberal arts colleges,

engineering and technological institutes, and large universities. Since the report appeared just over a year ago, other programs have been initiated. They take such varied forms as courses, institutes, centers and schools, illustrating many possible institutional organizational arrangements. And the University of Wisconsin at Green Bay has ecology as its only curriculum.

An interesting aspect of these different efforts is their varied points of origin in the institution. They have "nucleated" in colleges of engineering, of course, in biology, chemistry, meteorology, health sciences, physics, architecture, law, geology, political science, and to leap to the far end of the spectrum, in fine arts.

It should be noted here that the general area of political science has, for some time, been developing a major effort in the field of science and public policy where the increasingly vital place of science and technology in public policy matters has been studied. As environmental problems become among the most important being faced in public policy determination, then we find "environmentalists" and students of public policy drawn more and more intimately together.

I think it would be of interest now to describe some of the things we have been undertaking in our own organization, the State Education Department. As you may guess, the pressures on us and our perceived need to encourage environmental education activities have been great. Our Department is clearly committed to vigorous action in this field.

Our initial efforts have centered on the elementary and secondary schools for a number of reasons. The first is that our relationships and responsibilities to these institutions is more direct than those to institutions of higher education. Also, the values and attitudes necessary for living in an age of environmental concern are best imbued in the young. However, we have also pursued programs in areas other than those connected with the elementary and secondary schools, and they will be noted subsequently.

Over a year ago we established a departmentwide Environmental Education Task Force to attack the problem of determining how we could serve the State's educational institutions in developing programs in environmental education, and to stimulate interest in improving the beauty and the cleanliness of our surroundings. A number of conferences were held, curriculum materials for grades K-12 were developed and distributed to the elementary and secondary schools, and teacher training programs were undertaken. Many individual schools had already been busy with these tasks before our own programs got underway and many of the experiences and talents from this source, as well as from university and museum sources, were used to complement our own efforts. We vigorously supported and furnished resource materials for the April 22 Earth Day movement and found the schools and the general academic community of the State extraordinarily responsive and interested. This is not to imply that our efforts created this climate but it was satisfying to be a part of it. A request has been submitted to the Legislature

this year for funds to continue and increase support of activities in environmental education. We intend to give environmental education pride of place in the educational program in an effort to change attitudes behavior and values.

In the higher education area, this Conference is one example of our interest in your activities and concerns with environmental problems. Also, surveys have been made of the educational and research resources of the State's colleges and universities in a number of areas dealing with the environment: in ecology, in environmental law, and in engineering, management, and architecture. Reports of these surveys will be distributed widely within the next couple of months. We are also seeking to encourage cooperation among the various institutions developing the public policy programs alluded to before.

A continuing study is underway to look into the employment of scientific and technical manpower in municipal and local government. The educational rationale for doing this is that as these levels of government become increasingly involved in dealing with their environmental and other problems requiring technically trained personnel, the universities and colleges are more and more likely to be drawn into new relations with their local governments. These educational institutions are most important sources of expertise and such activity will satisfy some of the great pressure on campuses to get involved in something "relevant." Working on urban, municipal and local government projects to protect the environment has become a respectable

and high status activity.

I'd like to mention finally a part of the Education Department having important responsibilities and a long history in environmental affairs, one with which many of you are probably not familiar. It is the New York State Museum and Science Service. In addition to its exhibits, the Museum for many years has been conducting courses in ecological topics for classes of visiting children and has been supplying kits of materials to individual schools.

The Science Service is a group of three research organizations doing surveys in geology, biology and archeology. They have a history going back to the early 1800's. The responsibility of the first two is to provide basic geological and biological data for the State through a variety of fundamental and applied research programs. The value of those data to workers in the environmental field is obviously invaluable.

These programs and activities are not nearly all that should be done. More is being planned and more will be undertaken. I did want to give you an idea, however, of what our own efforts are in the environmental field and to let you know that exhortations for action include ourselves.

At this point, after having declaimed upon the university and importance of environmental problems, I would like to suggest a reorientation of the way of looking at environmental problems and state that they are only a part of a much larger and more fundamental problem. This more basic problem finds

expression in the incredible paradoxes we see throughout the world. Such basics as food, shelter, personal freedom, health services, and justice are inequitably distributed throughout the world. Fundamentally, most of the same conditions that brought these dislocations about also contributed to our environmental problems.

A host of people have expressed thoughts along these lines. Let me mention just one that probably sums it up as well as any. I quote from a recent article by B. R. Dorsey, President of the Gulf Oil Corporation:

In the richest society in history, millions of Americans are impoverished and hungry; our schools are overcrowded, teachers are underpaid and in short supply; crime rates are soaring; social services of every kind are breaking down -- police protection, fire services, garbage collection; our cities are decaying, and the blight is beginning to spread into the surrounding suburbs; the air over these cities is filling up with our waste products, and our waterways are increasingly polluted; our highways are overcrowded and public transportation systems are antique and inadequate.

Internationally we face a world which is wracked with crisis, essentially resulting from the appalling contrast between the concentration of the world's population in the underdeveloped countries and of the world's wealth and power in the advanced ones. The former are largely in the southern part of the world and the latter except for Australia and New Zealand, in the north. Poverty is accompanied by backwardness -- that is, by low levels of literacy and basic skills, inefficient economies, and outmoded political and social institutions. At a time of rapid change, backwardness leads to instability and disorder.

In addition, except for Japan, the rich northern countries are all of Western culture and are predominantly Caucasian in race, while the poor countries are culturally non-Western and are overwhelmingly non-white.

This imbalance between the rich, white, Western nations of the north, the poor, colored, non-Western nations of the south is rapidly increasing. -- the rich are getting richer, and the poor are getting relatively poorer. This imbalance, and the existence of what have been called "ghetto continents," may be the potentially most disastrous problem which we will face in the remaining years of this century.

I might interject here that these global problems are also responded to by the Education Department through a number of programs. I have often observed that in other countries when people become dissatisfied, governments are overthrown and rulers fall. In this country, when people become alarmed and recognize a social problem, we add a new course to the public school curriculum.

This is somewhat facetious but does, I think, show the great importance we attach to education for dealing with general social problems. In addition, then, to specific environmental programs, others, designed to deal with problems such as those in drug abuse, racism in a number of forms and effects of poverty on learning, as well as programs for developing greater international and cultural understanding have been undertaken by us. We have an office in India, for instance, for the development of curricular materials.

Up to this point, I have implied or mentioned in general that many factors, such as economic, cultural, psychological and political ones, all interacting with one another, determine the state of our society and more specifically that of our environment. We have not yet attempted, however, to see how engineering and technology fit in, and that, after all, is the basis for our coming together.

Most of the environmental problems facing us can be associated in some way with engineering or technological developments. This is not stated as an indictment but it is a simple fact that within the context of our cultural and societal traditions and practices, the by-products of the marvelous technological achievements we have all demanded, encouraged, and supported, have created the great environmental perils that we now recognize and that now confront us.

It has been well argued that pollution and poverty are products of a failure to devise adequate social controls on technology and that economic development no longer serves human welfare and is rapidly denigrating the human condition and the quality of life.

A very good commentary on these points has been made in the same article by B. R. Dorsey referred to before:

Although these problems have grown out of our success in solving other problems, it would be wrong to conclude that they were unavoidable. We are not, as some critics of our social system claim, slaves to a mindless technology which will inevitably destroy our best human values through unforeseeable negative consequences of our achievements. Actually, as has been pointed out by Emmanuel Mesthene, the Director of Harvard's Program on Technology and Society, these negative consequences of technology have resulted from the autonomy that our economic and political institutions grant to individual decision making.

Dr. Mesthene points out that, in our society, corporations are always on the lookout for new technological opportunities, and they hire scientists and engineers to invent such opportunities. In deciding whether to develop a new technology, the company makes cost-benefit calculations and proceeds if they expect their

benefits to exceed their costs. Until now, the entrepreneur has not been expected to consider deeply the probable benefits and costs of the new development to society as a whole. Thus, most of the problems discussed here, and many others which will easily come to mind are, in Dr. Mesthene's words, "with us in large measure because it has not been anybody's explicit business to foresee and anticipate them. They have fallen between the chairs of innumerable individual decisions to develop individual technologies for individual purposes without explicit attention to what all these decisions add up to for society as a whole and for people as human beings.

Many of the individuals who are caught up in the situation described by Dr. Mesthene are and will continue to be graduates of engineering colleges. They will seek to pursue their profession and earn their livelihood in large corporations and small businesses, as municipal, state and federal employees, as independent consulting engineers and as members of the academic community. As they practice their profession, they will continue to produce the techniques, machines and goods used in our society and, hence, will act as agents of profound influence and change. They will not, of course, be independent agents but will be governed by the values and practices of our business institutions, our market places, our domestic and international trade policy and our laws. All of these and the other factors already mentioned, the social, cultural, political and legal, will operate to develop the characteristics of the society in which we will live.

One might summarize and say that this is where we now stand. We have environmental problems. We perceive, however inexactly, that there are a host of factors determining them through very complicated

inter-relationships and there are many identifiable groups involved in these relationships. One of the most important of these and one of the most influential by the nature of their profession, are engineers. There are the colleges of engineering who educate these individuals. How should they do so?

The purpose of the Conference is to try to answer this question. The purpose is stated to be an inquiry into how the State's engineering colleges in their instructional and research programs may most appropriately respond to the needs created by environmental problems. What shall these institutions do?

As Robert Hutchins used to say, when anything can be done, you might as well do the right thing. And who was it who said that what isn't worth doing, is not worth doing well.

Roger Reville, Director of the Harvard Center for Population Studies, describes the following role of education:

The functions of education in the maintenance and improvement of environmental quality are threefold: production of the many kinds of specialists who will be required to deal professionally with the problems -- formulation and inculcation of the moral and intellectual values on which environmental improvement must rest -- and creation of a heightened sensitivity among young people to the world around them -- the ability to use their senses and to respond to what they perceive. In all three areas, the professional schools of the university with their emphasis on the relevance of teaching to the problems of the real world, the synthesis of science and art in professionalism, and the importance of action as well as thought, can contribute greatly.

A fundamental difficulty arises when we consider moral and intellectual values. For a variety of reasons, our universities have been more concerned with means than with ends. But in a world in which we have the means to do almost anything we want, the choice of what to do becomes crucial. In our society, only the universities have the intellectual breadth and humanist depth to give young people the basis for the development of tastes and the choice of goals. The teaching of values as a university function will require a major reorientation of faculty thinking.

I would contend that probably the simplest to attain of Revelle's three goals is the first, that of educating engineers to have the skills necessary to develop instruments and processes which can be used to solve the specific physical environmental problems we have --simplest, however, only on a relative basis.

I would, however, like to speak a bit about Revelle's other two educational goals for those being prepared to cope with environmental problems -- those goals encompassing matters of values, attitudes and sensitivity.

These are important for the engineer to enable him to function within a social order that is in a state of great flux. The very least that will be required of the engineer, not only, I may add, as a professional practitioner, but also as a manager, executive and policy maker as he progresses from one role to another in his career, is that he have the ability to respond to rapidly changing rules, to changing constraints upon his action, to changing "boundary conditions." These will be imposed by such factors as changing standards and laws and community and social pressures.

However, situations will have to be faced which I think will be even more demanding. Let me quote from an article by Professor Paul

B. Daitch of Rensselaer Polytechnic Institute:

Today's engineer must be a humanist . . . today . . . everybody is talking about engineering problems and in a manner that extends far beyond immediate technical knowhow.

The engineer must relate to technology, it is true, but the good engineer must also be sensitive to the social forces of his time.

The social forces existing today are indeed unusual and are things not immediately thought of when planning a curriculum. For example, who would have expected even only a few months ago to find the following full-page advertisement in our nation's major newspapers. It was placed there by the Polaroid Corporation, a preeminent technological corporation:

We abhor apartheid the national policy of South Africa . . . the apartheid laws separate the races and restrict the rights, the opportunities, and the movement of non-white Africans. This policy is contrary to the principles which Polaroid was built and run. We believe in individuals . . . Whatever the practice is elsewhere, South Africa alone articulates the policy contrary to everything we feel our Company stands for. We cannot participate passively in such a political system nor can we ignore it. That is why we have undertaken this experimental program.

The program they referred to, as you may well know, has to do with supporting the education and raising the salaries and status of non-white employees of Polaroid's businesses in that country, contrary to the expressed spirit of the laws of that foreign land.\* This is not directly connected with environmental problems but is an illustration of a form of social action by

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\* To encourage participation in the governmental process, Polaroid Corp. also paid for any political telegrams sent by its 9000 employees to elected officials during the Cambodia/Kent State/Jackson furor last spring. It intends to continue this policy in the future.

the industrial technological community which exemplifies the changing attitudes in our society. These attitudes will, it is predicted, also find expression in the environmental field.

Let me give another illustration of a new situation, an ethic or code perhaps with which engineers, or any employees, are being confronted and with which they and their employers will soon have to deal. I quote some excerpts from an article by Ralph Nader, that friend of all corporations, entitled "A Code for Professional Integrity" in the January 15 issue of the New York Times:

Staying silent in the face of a professional duty, almost invariably articulated in the profession's canons of ethics, has direct impact on the level of consumer and environmental hazards. This awareness has done little to upset the slavish adherence to "following company orders."

Employed professionals are among the first to know about industrial dumping of mercury or flouride sludge into waterways, defectively designed automobiles, undisclosed adverse effects of prescription drugs and pesticides. They are first to grasp the technical capabilities to prevent existing product or pollution hazards. But they are very often the last to speak out, much less refuse to be recruited for acts of corporate or governmental negligence or predation.

Nader goes on to further discussions along these lines and at the end of his article suggests three basic changes that he recommends. Let me quote the third:

Third, professional societies should clearly stake out their readiness to defend their colleagues when they are arbitrarily treated for invoking their professional ethics toward the corporate or government activity in which they were involved. Most of the established professional societies or associations never challenge corporate or governmental

treatment of lawyers, engineers, scientists, or physicians as the American Association of University Professors has done on occasion for university teachers denied academic freedom. And where there is no willingness to challenge, there is less willingness for the employee to dissent.

The particular reason for citing these very unusual examples is that I believe them to be harbingers of the future. They illustrate new situations which are developing, old ones which are coming into sharper focus. They are actual problems that will have to be dealt with by those whose careers will be identified with the engineering profession, not only the bench and design engineers but the managers, executives and decision makers who began their careers and obtained their formal education in engineering institutions.

Providing the appropriate education for those who will assume such critical roles, for those who will have to adapt and build and guide the technological enterprise necessary for the complicated, and uncertain and rapidly changing society is the great challenge facing us all.

Maybe you saw recently a report from MIT which urges wide revisions in curriculum and research procedures in order to enhance the social awareness and responsibility of scientists and engineers. It urged that MIT's historic commitment to scientific excellence be coupled with a concern for social responsibility in the use of the knowledge acquired. The report stressed the cultivation of a deeper understanding of the social consequences of science and technology to the extent that such understanding could be built

into the curriculum. Finally, the report took a look at the national effort aimed at transforming and renewing our national sense of purpose and suggested that MIT take a major role in this by taking seriously the intellectual problem of relating knowledge to values.

One of my humanist friends at the elementary and secondary level commented that education today requires putting the emphasis on man, not only in the humanities, but also in the social sciences and the sciences

"for then we will have, to borrow from C. P. Snow, an education for the third culture, with study in the humanities and study in ecology complementing each other."

Only man who has studied man can live effectively as man. Putting men on the moon or getting rid of air, water, and noise pollution will be meaningless unless we can do something about human relations, about ethics, about values. I do not like the way in which we move from one scientific venture to another without some serious human ventures.

I think it is a healthy sign in the younger generation that there is a rebellion, not against reason, but against reason, as someone has remarked, narrowly defined as a quantitative calculus that avoids human needs and values. I think the younger generation is especially sensitive to the need for a "harmoniously functioning human ecology" and for recapturing, to quote a recent writer, "on the high level of today's advanced cultures something of the union of man and his surroundings achieved by earlier and more primitive cultures."

I would hesitate to make a prediction about the future. It is sometimes foolish and perhaps I should heed the advice of a certain Episcopal bishop in

Virginia who was asked by a parishioner whether a non-Episcopalian could enter the Kingdom of Heaven. "Frankly," he said, "the idea had never occurred to me; but if he is a gentleman, he will not make the attempt."

But I join Dean Goodlad of the Graduate School of Education at UCLA in saying:

All that we can predict with certainty is that the central issue of the 21st Century, as it is of this one, will be the struggle to assert truly human values and to achieve their ascendancy in a mass, technological society. It will be a struggle to place man in a healthy relationship with his natural environment; to place him in command of, rather than subservient to, the wondrous technology he is creating, and to give him the breadth and depth of understanding which can result in the formation of a world culture, embracing and nurturing within its transcending characteristics the diverse cultures of the world today.

Frank Kille told me that in preparing this preach, he hoped I would keep in mind that 1971 is the 4,669th year in the Chinese lunar calendar and that it was the Year of the Boar. I hope I haven't been one and that some of these remarks lie within the orbit of your interests.

Thanks for joining us in this conference.

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